Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Environmental Sciences 10 (2011) 1654 – 1660
Procedia Environmental Sciences

2011 3rd International Conference on Environmental Science and Information Application Technology (ESIAT 2011)

# Dynamic Variation of Glaciers in Bomi County of Tibet during 1980~2010

Xiang Lingzhi[1],Liu Zhihong[1],Liu Jinbao[1],Zou Xiao[1]

*1Chengdu University of Information Technology, Chengdu 610025, China*

*tongxianghe@gmail.com*

**Abstract**

Applied by remote sensing (RS) and geographical information system (GIS), an analysis of big glaciers dynamic variation was shown during the past 40 years in Bomi County utilized the meteorological data provided by Bomi Meteorological Station. The results showed that the area of glacier in Bomi County has experienced a general shrinkage in area from 1980 to 2010; it has decreased 25.74km2 in the recent 40 years. Among them, the areas of big glaciers during 1980 to 1990 contribute to 64.6% of the total area loss. The records in Bomi Meteorological Station indicated that the glacier shrinkage was mainly subjected to continuous temperature rise, especially after 1980.


Selection and/or peer-review under responsibility of Conference ESIAT2011 Organization Committee.

Keywords: Bomi; dynamic variation of glaciers; Landsat; climate change

## 0 Introductions

The Tibetan Plateau is the region of more developed mountain glacier in mid-low latitude. Since 1980s, all of the glaciers in Tibetan Plateau are shrinking with obvious special and time characteristics [1]. As the subject of Tibetan Plateau, the Tibet not only developed a very large-scale mountain glacier, but also a large-area maritime glacier. The latter is mainly distributed in the southeast of Tibet, especially the joint zone of Nyainqentanglha and Shubolaling Mountain; it's the largest monsoon maritime glacier zone in China. Recently, the map through by satellite remote sensing has brought good news: A largest glacier group was found in Bomi in Tibet, about 42 glaciers, two of the three greatest Chinese marine glaciers were over there too [2]. One-third of the world's people depend on the water originated from the Tibetan Plateau, but the glacier is shrinking now. So it is extremely urgent to monitoring the change of glacier [3].

It is infeasible to monitor glacier with routine observation methods, but with the development of GIS, RS and GPS, the '3S' technology provide an effective method for glacier change monitoring [4~6]. Especially the satellites with high resolution give a strong technical support to glacier change monitoring.


Selection and/or peer-review under responsibility of Conference ESIAT2011 Organization Committee.
doi:10.1016/j.proenv.2011.09.260

The application of remote sensing has become an indispensible method for glaciers dynamic changes monitoring and studying. Shang guan donghui [7] analyzed the dynamic changes of glaciers in western Nyainqentanglha during 1970 to 2000 using Land sat ETM data with RS, and gave the reason why it changed .

This paper selected Bomi County as study area, used RS and GIS technology, TM and ETM data, DEM and the meteorological data provided by Bomi Meteorological Station, analyzed the glacier change and the reason of glacier variation.

## 1 The study area

Bomi, located in the southeast of Tibet and north bank of Palong River, its geography coordinates is between 94°~ 96°E and 29°~30°N. With a high-in-the-North-and-lower-in-the -South terrain, it is lined with mountains, Palong Valley and Yigong Valley are lay in the midst, covering an area of 16795km2. The highest peak is Mingpubudeng Mountain with 6118m above sea level in that area, and the mean altitude is 4332m [2].

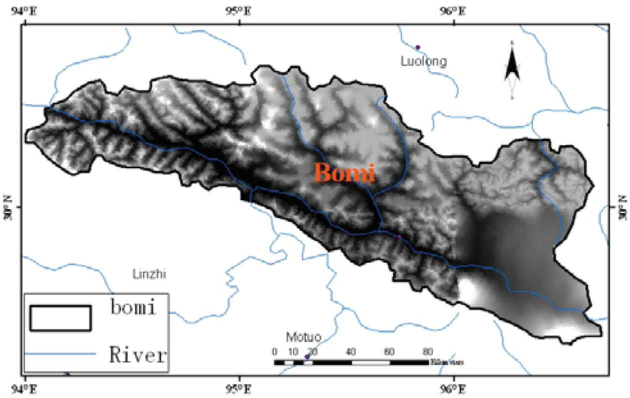



**Fig 1** The location of the study area

There are many maritime glaciers developed in Bomi, for example Kaqin, Zepu, Ruoguo, Guxiang, especially the largest marine glacier in China, Kaqin Glacier located in Yigong Bomi, they are 5990m and 5946m above sea level of the two high peak respectively, covering an area about 90km2.

## 2 Methods

### 2.1Date sources

The paper selects 12 RS images of 1990s, 2000s and 2010s include TM and ETM. The DEM and vector data of glaciers of 1980s are provided by Laboratory of Remote and GIS, CAREERI, CAS.

The auxiliary data includes the meteorological data (rainfall and temperature), and related technology research literature material l (table 1).

**Table 1** Data used in this study

| Type | Path/Row | Date | Resolution(m) | Date sources |
|---|---|---|---|---|
| LandsatTM | 134/40 | 1988.10.27/ 2007.04.15 | 30 | Global Land Cover Facility(GLCF) |
| | 135/39 | 1987.12.03/ 2007.06.09 | | |
| | 135/40 | 1990.11.09/ 2008.10.17 | | |
| | 136/39 | 1988.10.09/ 2009.02.13 | | |
| LandsatETM | 134/40 | 2001.10.23 | 30 | |
| | 135/39 | 1999.09.23 | | |
| | 135/40 | 2001.11.05 | | |
| | 136/39 | 2001.10.21 | | |

**2.2Methods**

With a high reflectivity in band 1, 2, 3, 4 and sudden fall in band 5, 7, this can be used to distinguish cloud from glacier easily. So this paper first chooses band 5, 4, 3 to false color synthesis, and then interprets the big glaciers(more than 20km$^2$) of three periods using ArcGIS (error controlled within 1pixel), the steps are shown in Figure2.

After interpretation completed, this paper gives a statistical analysis of results in different stages, and then shown a dynamic variation in different areas and periods utilizing DEM and meteorological data.

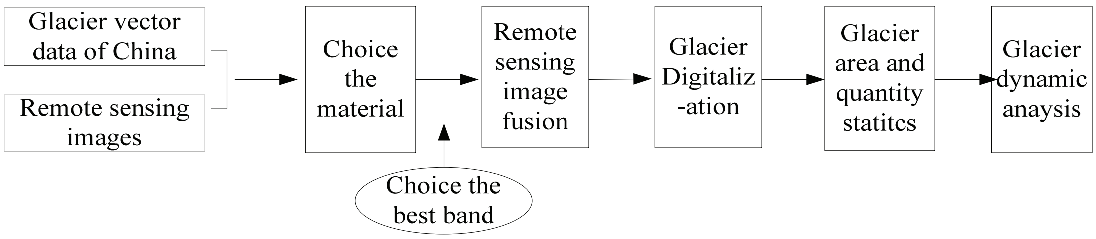



**Fig 2 Data processing**

**3 Results**

## 3.1 Spatial characteristics of glacier distribution

The mean altitude of Bomi is 4223m, valley glaciers are mainly developed here. It has a total of 2040 glaciers covering an area of 4382.5km$^2$; contribute to 26.1% of the county.

According to the statistics, glacier are mainly distributed at the altitude between 4000~ 6000m, and the area is 4086 km$^2$, contribute to 93.2% of the total. But below the 3000m, there are only 1km$^2$ glaciers, account 0.02% to total area (Table 2).

**Table 2** Glacier area distribution in Bomi County

| DEM | Area[km$^2$] | Percentage of total area[%] |
|---|---|---|
| 2139~3000 | 1 | 0.02 |
| 3000~4000 | 198 | 4..52 |
| 4000~5000 | 2137 | 48.70 |
| 5000~6000 | 1949 | 44.48 |
| 6000~7000 | 100 | 2.28 |
| Total | 4382 | 100 |

Slope is a micro- indicator, which is one of the most important terrain factors [8]. This paper uses ARCGIS statistics function to extract the slope information of Bomi County, and the statistics the glacier area and proportion graded. According to the classification standards of 7°, 15°, 25°, 35°, 45°, the disposition of the glacier in 1980s are shown in Table 3. From the table, we can see that, the glaciers mainly distribute between 7°and 35°, the rest are only account for a small percentage of totals.

**Table 3** Glacier slope distribution in Bomi County

| Slope | Area/[km$^2$] | Percentage of total area [%] |
|---|---|---|
| ＜7° | 56 | 1.28 |
| 7°~15° | 2031 | 46.35 |
| 15°~25° | 1333 | 30.42 |
| 25°~35° | 819 | 18.69 |
| 35°~45° | 137 | 3.13 |
| ≥45° | 6 | 0.14 |
| Total | 4382 | 100 |

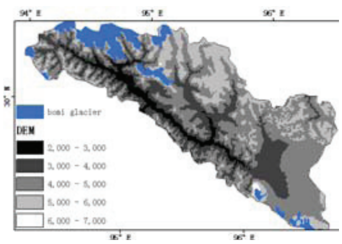



**Fig 3** Modern glaciers

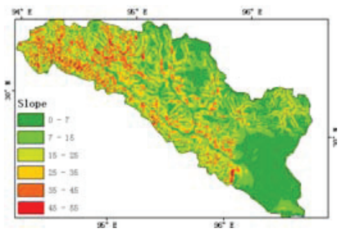



**Fig 4** Slope of Bomi County

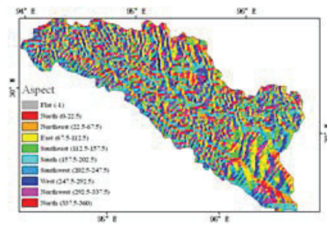



**Fig 5** Aspect of Bomi County

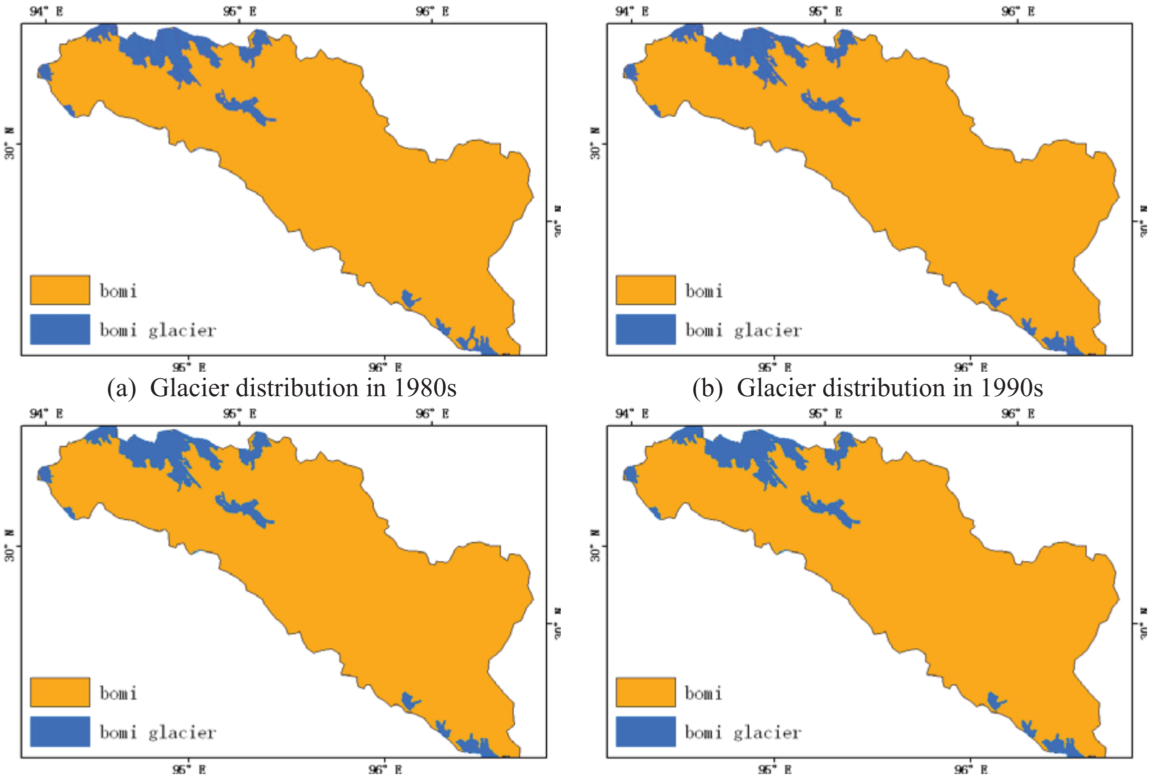
**Distribution**

Bomi, with a high-in-North-and-lower-in-South terrain, it's all Nyainqentanglha in south, west, northeast, the eastern region is the remaining branch of Shubolaling Mountain, south region is the Himalayas branch; and the central region is valley area. Because of the special geographic position and terrain, make Bomi become the largest distribution of maritime glaciers in China.

From the Figure 3 and Figure 4, we can see that the big glaciers are concentrate on the northeast of researched area. With east part of Nyainqentanglha of northwest to southeast, and can clearly see that the glacier distributed in the south are more than the north. Although the eastern south slope of Nyainqentanglha accepts more solar radiation heat than north does, southern slope is in the turning of Brahmaputra River at south of Tibetan. The southwest monsoon level warm-moist air flow into highland aisle windward slopes, rainfall is rich, abundant rainfall supplies to offset the solar radiation on the part if glaciers melt [9], which makes the glacier area in the southern slope, is more than North Slope [7]. A few big glaciers are selected to be analyzed, so no change can be found obviously in quantity.

### 3.2 Time characteristics of glacier distribution

This paper is based on TM and ETM images; the distribution of big glaciers in 1980s, 1990s, 2000s, and 2010s by visual interpretation is acquired. As shown in Figure 6(more than 20km$^2$).




(a) Glacier distribution in 1980s (b) Glacier distribution in 1990s

(c) Glacier distribution in 2000s (d) Glacier distribution in 2010s

**Fig 6** Glacier distribution of four periods

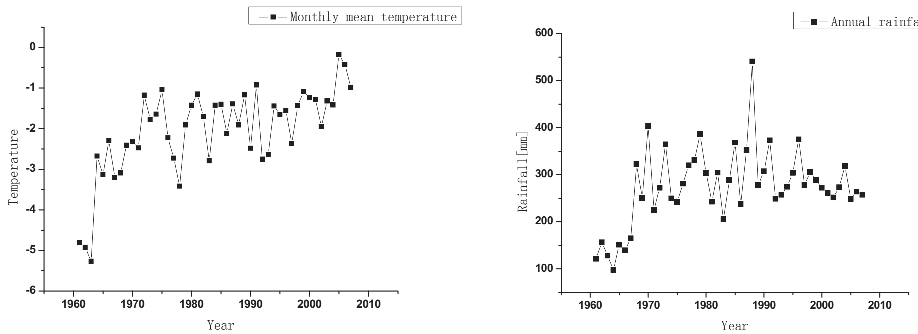
The distribution of glaciers analyzed by conventional way is shown in Table 4. In the quantity, there is no change. In the study area, it has decreased 25.74km$^2$ in resent 40 years, changed 1.62%, about 2.57km$^2$·a$^{-1}$. Among them, the area of big glaciers during 1980~1990 contribute to 64.6% of the total area loss, about 16.62km$^2$, change rate 1.66km$^2$·a$^{-1}$. And 1990~2010, it has decreased 9.11km$^2$, change ratio is 0.58%, change rate 0.91km$^2$·a$^{-1}$.

**Table 4** Variations of glacier during 1980~2010 of Bomi County

| Date | Quantity/[strip] | Area/[$km^2$] | Area va/[$km^2$] | Area change ratio/[%] | Area change rate/ [$km^2 \cdot a^{-1}$] |
|---|---|---|---|---|---|
| 1980 | 24 | 1592.78 | | | |
| 1990 | 24 | 1576.16 | -16.62 | -1.04 | -1.66 |
| 2000 | 24 | 1570.62 | -5.54 | -0.35 | -0.55 |
| 2010 | 24 | 1567.04 | -3.57 | -0.23 | -0.36 |
| Total | | | -25.74 | -1.62 | -2.57 |

## 4 Effect of climate change on glacier variations

Mountain glacier, especially those which located in temperate zone, is considered to one of the best natural indicator of climate change [10]. Recently, a lot of literatures gave reports that the mountain glacier is shrinking all over the world, massive small glaciers have disappeared before be found by people.




**a Monthly mean temperature** **b Annual rainfall**

**Fig 7** Variation tendency of temperature and rainfall

during 1960-2010 from the weather stations of the Bomi County

Temperature and rainfall, the main factors in climate condition, affect the ablation and cumulative process of glaciers respectively. Glacier will be ablate when the temperature rising, and cumulate when rainfall rising [11]. Temperature is the key factor of glaciers change [12, 13]. The change of glaciers in Bomi County and climate change are inseparable in past 50 years. According to the meteorological data during 1986~2010, this paper figure out the monthly mean temperature and the annual rainfall, and drawn into line charts (Figure 7).

According to the records during the period 1960s to 2010s, it can see the monthly mean temperature is below 2.0℃, and the annual rainfall is 274.3mm. From its linear trend, the temperature had risen obviously consistent to the Tibetan Plateau in the past 50 years [14, 15]. But not great change with rainfall, this is mainly because the India Ocean Warm Current makes abundant rainfall in Bomi compared with other parts of the Tibet. Figure 7 shows that there's a temperature peak in 1980 to 1990, but the rainfall have a low in the same time, it provides a reason for glacier ablation. And after 1990s, the temperature and rainfall have changed not great; promoted the less change of glaciers relatively.

But from Figure 7, a sudden rise in temperature happened from 2010, it will affect the speed of glacier certainly.

## 5 Conclusions

Some conclusions can be drawn as follows:

（1）Research show that, the quantity and area of glaciers in Bomi have decreased significantly during 1980 to 2010. The area of glaciers distributed in south slope is greater than north; while the glaciers are shrinking always, it has decreased 25.74km2 of big glaciers in 1980 to 2010, changed 1.62%, change rate is 2.57km2•a-1.

（2）Combined with the meteorological data, this paper found that the terrain and climate all affect the space change of glacier distribution. Temperature rising is the main reason for glaciers ablation, but the rainfall influenced little.

## References

[1] Yao Tandong, Wang Youqing, Liu Shiyin. Recent glacier retreat in High Asia in China and its impact on water resource in Northwest China. Science in China, Vol. 47(2004), p. 1065~1075

[2] Feng Feng. Information on http://www.kjdb.org

[3] Qian Geming. Information on http://wuxizazhi.cnki.net/Article/ZSLL200703008.html

[4] Ding Yongjian, Li Xin, Cheng Guodong. Potential Direct Solar Radiation Based on GIS and Glacier Mass Balance. Journal of Glaciology and Geocryology, Vol. 20 (1998), p. 157~162

[5] Framk P, Andreas K, Maisch M, et a1. The new remote-sensing-derived Swiss glacier inventory methods. Annals of Glaciology, Vol. 34(2002),p. 355~361

[6] Wei Hong, Ma Jinzhu, Ma Mingguo. Study on charges of glacier and glacier lakes in the Pumqu Basin based on RS and GIS. Journal of Lanzhou University, Vol. 40 (2004), p. 97~100

[7] Shangguan dongyin, Liu Shiyin, Ding Liangfu. Variation of Glacier in the Western Nyainqentanglha Range of Tibetan Plateau during 1970~2000. Journal of Glaciology and Geocryology, Vol. 30 (2008), p. 204~210

[8] Guo Liupin, Ye qinghua, Yao Tandong. The Glacier Landforms and the Changes of Glacier and Lake Area in the Mapam Yumco Basin in Tibtean Plateau Based on GIS. Journal of Glaciology and Geocryology, Vol. 29 (2007), p. 517~524

[9] Liu Zongxiang, Su Zhen, Yao Tandong ,et al. Resources and distribution of glaciers on the Tibetan Plateau. Resource Science, Vol. 22 (2000), p. 49~52

[10] Houghton J T, Ding Y, Griggs D J. Contribution of Working Group to the Third Assessment Report. Climate Change, 2001

[11] Xu Junli, Liu Shiyin, Zhang Shiqiang. Glaciers fluctuations in the Karamilan-Keriya River Watershed in the past 30 years. Journal of Glaciology and Geocryology, Vol. 28 (2006), p. 312~318

[12] Zhen Su, Ya Fengshi. Response of monsoonal temperate glaciers to global warming since the Little Ice Age.Quaternary International, Vol. 97 (2002), p.123

[13] Li Zhongqin, Shen Yongping, Wang Feiteng. Response of Glacier Melting to Climate Change-Take Urumqi Glacier No.1 as an Example. Journal of Glaciology and Geocryology, Vol. 3 (2007), p. 132~137

[14] Liu X, Chen B. Climatic Warming in the Tibetan Plateau During Recent Decades. International Journal of Clim atology, Vol. 20 (2000), p. 1729~1742

[15] Wu S, Yin Y, Zheng D,et al. Climate Changes in the Tibetan Plateau During the Last Three Decades. Acta Geographica S inica, Vol. 60 (2005), p.3~11